Solutions and Solubility Unit Grade 11

Lesson Sequence	Lesson Plan Concept	Names
Concentration	With a focus on ionic and molar concentrations, the mathematical relationships central to understanding of solutions are developed and explored.	Nicole Ross, Henry Xu
Solution Stoichiometry	Building on their knowledge of concentration, students will be introduced to the concept of stoichiometry as it relates to solution chemistry. Class examples will be done together, practice group questions will be given as well as a relevant environmental application and extention.	Courtney Turner, Nicki Ross

Solution Lesson Plan Rationales

Solutions and Solubility Unit; Concentration Lesson

Within our Solutions and Solubility unit, we decided to do our lesson plan on Concentration. More specifically, we focused on molar and ionic concentrations. We wanted to cover and explore this topic because it is an important concept for students to learn, and we found it is an area that a lot of students seem to struggle with understanding. It is also a topic that will lay some foundation for Nicole and Courtney's lesson plan.

Math in chemistry may be a little more abstract than some students are used to. We therefore wanted to give enough background and examples to the students so they could understand the basic concepts of molar and ionic concentration. As this topic can sometimes seem dry to students, we did not want to spend too much time lecturing. We decided to have a quick overview on concentration, and then continue with an explanation of molar concentration, ionic dissociation (which will be built upon in Nicole and Courtney's lesson plan), and ionic concentration. The majority of the class would then be spent on having the students figure out a set of problems on their own, in a controlled environment. We felt this would be the best strategy for learning a math based concept. This way, they could seek help from the teacher or their peers if necessary. While the students are working, the teacher could then walk around the room and offer individual help to those who need it, and assess the students' learning.

Solutions and Solubility Unit; Stoichiometry

Given that stoichiometry is often a source of great frustration to many students, we attempted to include hands-on, and relevant examples in our lesson to encourage understanding of this concept. Building on the math skills learned in the concentration unit plan, the students will learn how to apply this math in solving word problems. To model the strategy for answering these types of questions, examples are performed at the board as a class. Then the students will have an opportunity to assess their own learning by doing problems within a group and can receive help both from the teacher as well as their peers. Groups will be assigned according to ability level so that the teacher may work closely with students who may have difficulty with this concept. An assessment of learning activity is included at the end of the class so that the teacher has an idea of general understanding of the class.

Unit Plan

Lesson 1: Intro to Solutions - pre-assessment questions - classifying solutions - testing solubility - properties of solutions	**Lesson 2: Factors that Affect Solubility** - solvents; water - polarity - like dissolves like	**Lesson 3: LAB for Factors** - lab design to test factors - carry out lab - discuss results in groups	**Lesson 4: Concentration** - molarity	**Lesson 5: Concentration cont.** - group work activity - dilutions
Lesson 6: Preparing Solutions - flask types and accuracy - mass accuracy - concentration determination	**Lesson 7: Reactions in Aqueous Solutions** - quiz (20 min) - demo	**Lesson 8: Ionic Equations and Reactions** - ionic dissociations - elements that form ionic bonds, why.	**Lesson 9: Stoichiometry** - intro to concept - practice problems - group work	**Lesson 10: Stoichiometry** - precipitation - $C1V1 = C2V2$
Lesson 11: Water - water quality: factors, determination - water pollution	**Lesson 12: Water** - water purification - waste-water treatment	**Lesson 13: FIELD TRIP to Water Treatment Facility**	**Lesson 14: Filtering** - quiz (20 min) - filter activity/lab: design filter, test it	**Lesson 15: Acids/Bases** - pH - demo
Lesson 16: Acids/Bases - reactions of - strong acids/bases - weak acids/ bases	**Lesson 17: Neutralization** - reactions - real world examples	**Lesson 18: LAB for Acids/Bases** - titration	**Lesson 19: Review/Study day** -Jeopardy style review day	**Lesson 20: Unit Test**

Unit and Title of Lesson: Solutions and Solubility - Solution Stoichiometry I

Courtney Turner, Nicki Ross

BIG IDEAS:
- properties of solutions can be described qualitatively and quantitatively, and can be predicted.
- people have a responsibility to protect the integrity of Earth's water resources.

MINISTRY EXPECTATIONS:

E1. analyse the origins and effects of water pollution, and a variety of economic, social, and environmental issues related to drinking water. E1.1

E2. investigate qualitative and quantitative properties of solutions, and solve related problems. E2.2, E2.3, E2.4, E2.5, E2.6

E3. demonstrate an understanding of qualitative and quantitative properties of solutions. E3.2

PRIOR KNOWLEDGE:
- concentration
- molarity
- calculation of molecular mass
- C = n/V

STUDENT LEARNING GOALS:
- understand solution stoichiometry and its utility in relation to real world applications.
- identify the limiting reagent of a reaction and calculate the excess amount of reactant.

LIST MATERIALS
- ❑ 1 x box graham crackers
- ❑ 2 x bars of chocolate
- ❑ 1 x bag of marshmellows
- ❑ 1 x pkg of paper plates

APPENDICIES
- ❑ A.1 S'more activity
- ❑ B.1 Board notes
- ❑ B.2 Group work handout
- ❑ B.3 Group work answers
- ❑ C.1 Four corners activity
- ❑ C.2 Homework questions
- ❑ C.3 Homework answers

	T/L STRATEGIES	RATIONALE	ASSESSMENT
A. MINDS ON	**1) S'more stoichiometry** Activity/Debrief *A.1 S'more activity*	• Hands on application of prior knowledge. • Introduction to limiting reagent concept.	• Discussion. • Formulation of S'more equation. • AfL
B . ACTION	**1) Board notes and examples** • $HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(l)$ • $Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ *B.1 Board Notes*	• Model how to set up the problem and the steps to solve it.	• Class participation. • Praise and feedback
	2) Group work • Assign to groups of 3 • Circulate and help with problems *B.2 Handout* *B.3 Answers*	• Work through problems collaboratively.	• Group participation. • Self-assessment opportunity (AaL)
	3) Discussion of group work as a class *B.3 Group work answers*	• Bring class back together. • Let them present their work.	• Quality of discussion. • Presentation of problem/solution.
C. CONSOLID-ATION & CONNECTION	**1) Application to the environment:** Water contaminants: waste water *C.1 Board notes for Four corners introduction*	• Extension to STSE • Application of stoichiometry to real life.	• See next section.
	2) Four corners activity *C.1 Four corners poster*	• Using info given in discussion.	• Quality of the group work. • AoL

NEXT STEPS	**1) Homework** *C.2 Homework* *C.3 Homework answers* **2) Next class:** focus on precipitates, more practice with limiting reagents.	• Practice	• Homework to be reviewed next class, corrected only, AaL

A. 1 S'more Stoichiometry

- What is the composition of a S'more? (2 GC, 1 S, 1M)
- Break up into pairs with the person sitting next to you.
- **IMPORTANT: Do not eat your ingredients yet!**
- Distribute s'more kits to each group. (Kit's contain 6GC, 3M, 2S)
- Make s'mores using what you're given. Together, write your own chemical equation.
- How might we write that in a chemical formula format?
  - What would the reactants be?
  - What is the product?

2Graham Crackers (GC)$_{(s)}$ + 1Marshmellow (M)$_{(s)}$ + 1Chocolate Square (S)$_{(s)}$ → 1S'more$_{(s)}$

Reactants | Product

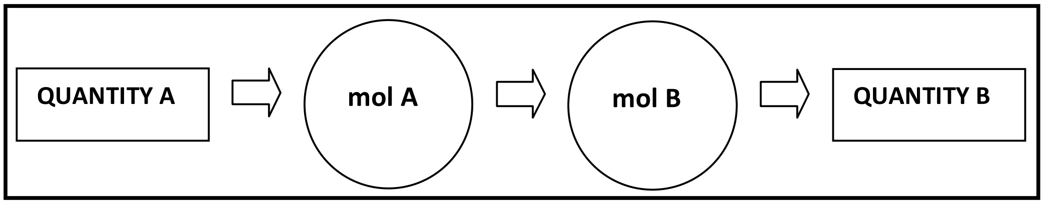
- What was the ingredient that you ran out of first? (S)
- In a chemical reaction, this would be called the limiting reagent: the substance that is totally consumed in a chemical reaction.
- In an industrial chemical reaction, this is usually the most expensive reagent. Why might that be? (Because they don't want expensive reagents to go to waste; to save money).

Vocabulary List

- **Stoichiometry:** the relationship between the relative quantities of substances taking part in a reaction or formation of a compound.
- **Mole:** the SI unit of amount of substance, equal to the quantity containing as elementary units as there are atoms in 0.012 kg of carbon-12.
- **Mole to mole ratio:** the quantitative relationship between the amounts of reactants and/or products in a given chemical equation.
- **Molar mass:** the mass of one mole of substance, usually measured in the units of g/mol.
- **Molarity:** unit of concentration; a number of moles of a solute in a number of litres of solvent.
- **Volume:** measurement of 3-dimensional space an object occupies.
- **Limiting Reagent:** the substance that is totally consumed in a chemical reaction; usually the most expensive reagent.

Agenda

1. S'more stoichiometry
2. Intro
3. Examples
4. Collaborative problem solving
5. Discussion
6. Homework



- Stoichiometry is a scary term, but all it means is relative quantities (amount) of substances in a reaction. We're focusing on solution chemistry so many of our problems will incorporate concentration.
- **IMPORTANT: Correct conversions are very important in stoichiometry, always label your units!**
- Let's do a few examples as a class.

1. Nitric acid reacts with sodium hydroxide in solution to give sodium nitrate and water.

$$HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(l)$$

a. Is our reaction balanced? (yes)

b. How many moles of water are formed when 25.0 mL of 0.100 M HNO_3 completely reacts with NaOH? Relate back to QA→molA→molB→QB diagram.

d. We have a quantity of HNO_3.How many moles of HNO_3 are reacting?

25 mL x L/1000 mL = 0.025 L

(Remember to convert mL to L b/c molarity is measured in mol/L)

0.025 L x 0.100 mol HNO_3 /L = **0.0025 mol HNO_3**

e. According to our reaction, for every one mole of HNO_3 reacted, one mole of H_2O is produced. This is called the mole:mole ratio. Here, it is 1:1

0.0025 mol HNO_3 x 1 mol H_2O/1 mol HNO_3 = 0.0025 mol H_2O

2. $Zn_{(s)}$ + 2 $HCl_{(aq)}$ → $ZnCl_{2(aq)}$ + $H_{2(g)}$

0.470 M HCl 1.50 g $ZnCl_2$

a. What is the volume (in L) of HCl that reacted?

b. Find molecular weight of $ZnCl_2$.

Zn 65.38; Cl 35.453; $ZnCl_2$ = 136.29 g/mol

c. Moles of $ZnCl_2$

1.50 g $ZnCl_2$ x 1mol $ZnCl_2$/136.29 g $ZnCl_2$ = 0.011 moles $ZnCl_2$

d. The mole:mole ration is 2:1

0.011 mol $ZnCl_2$ x 2 mol HCl/1mol $ZnCl_2$ 0.022 mol HCl

e. Given, 0.470 M HCl = 0.470 mol HCl/1 L

0.022 mol HCl * 1L/0.470 mol HCl = 0.0468 L HCl = 46.8 mL HCl

3. Using the previous example, if 1 g of solid Zn was used, what is the limiting reagent of the reaction? Remember, the limiting reagent is the substance that is completely consumed.

a. We know the moles of $ZnCl_2$ is 0.011.

b. Using the mol:mol ratio of Zn:$ZnCl_2$, which is 1:1, we know we must have had at least 0.011 mol solid Zn to start.

c. Using the molecular weight of Zn, 65.38 g/mol, we find we needed 0.719 g of solid Zn to produce 1.50 g of $ZnCl_2$. If we started with 1 g, then which is the limiting reagent (HCl was completely consumed). How much Zn remains unreacted? 1.00 g - 0.72 g = **0.28 g Zn**.

B.2 Solution Stoichiometry In-Class Worksheet

Balancing Equations and Simple Stoichiometry

Balance the following equations:

1) ___ N_2 + ___ F_2 $\rightarrow$ ___ NF_3

2) ___ C_6H_{10} + ___ O_2 $\rightarrow$ ___ CO_2 + ___ H_2O

3) ___ HBr + ___ $KHCO_3$ $\rightarrow$ ___ H_2O + ___ KBr + ___ CO_2

4) ___ $GaBr_3$ + ___ Na_2SO_3 $\rightarrow$ ___ $Ga_2(SO_3)_3$ + ___ NaBr

5) ___ SnO + ___ NF_3 $\rightarrow$ ___ SnF_2 + ___ N_2O_3

Using the equation from problem 2 above, answer the following questions:

6) If I do this reaction with 35 grams of C_6H_{10} and 45 grams of oxygen, how many grams of carbon dioxide will be formed?

7) What is the limiting reagent for problem 6? ___________

8) How much of the excess reagent is left over after the reaction from problem 6 is finished?

Consider the following equation:

$$Ca(OH)_{2(s)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2\ H_2O_{(l)}$$

9) How many liters of 0.100 M HCl would be required to react completely with 5.00 grams of calcium hydroxide?

10) If I combined 15.0 grams of calcium hydroxide with 75.0 mL of 0.500 M HCl, how many grams of calcium chloride would be formed?

11) What is the limiting reagent from the reaction in problem #10? __________

12) How many grams of the excess reagent will be left over after the reaction in problem 3 is complete?

B. 1 Solutions to Worksheet

Balance the following equations:

1) $1\ N_2 + 3\ F_2 \rightarrow 2\ NF_3$

2) $2\ C_6H_{10} + 17\ O_2 \rightarrow 12\ CO_2 + 10\ H_2O$

3) $1\ HBr + 1\ KHCO_3 \rightarrow 1\ H_2O + 1\ KBr + 1\ CO_2$

4) $2\ GaBr_3 + 3\ Na_2SO_3 \rightarrow 1\ Ga_2(SO_3)_3 + 6\ NaBr$

5) $3\ SnO + 2\ NF_3 \rightarrow 3\ SnF_2 + 1\ N_2O_3$

Using the equation from problem 2 above, answer the following questions:

6) If I do this reaction with 35 grams of C_6H_{10} and 45 grams of oxygen, how many grams of carbon dioxide will be formed?

When you do this calculation for 35 grams of C_6H_{10}, you find that 113 grams of CO_2 will be formed. When you do the calculation for 45 grams of oxygen, you find that 43.7 grams of CO_2 will be formed. Because 43.7 grams is the smaller number, oxygen is the limiting reagent, forming 43.7 grams of product.

7) What is the limiting reagent for problem 6? **oxygen**

8) How much of the excess reagent is left over after the reaction from problem 6 is finished?

21.5 grams of C_6H_{10} will be left over.

Consider the following equation:

$Ca(OH)_{2(s)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2\ H_2O_{(l)}$

9) How many liters of 0.100 M HCl would be required to react completely with 5.00 grams of calcium hydroxide?

Using plain ol' stoichiometry, you should find that it will require 0.0135 moles of HCl to react with 5.00 g $Ca(OH)_2$. Using the equation M = mol/L, this translates to 0.135 L of 0.100 M HCl.

10) If I combined 15.0 grams of calcium hydroxide with 75.0 mL of 0.500 M HCl, how many grams of calcium chloride would be formed?

2.08 grams

11) What is the limiting reagent from the reaction in problem #3? **HCl**

12) How many grams of the excess reagent will be left over after the reaction in problem 3 is complete? **13.6 grams of Ca(OH)**

C.1 Wastewater Four Corners

Wastewater treatment, One of the main purposes of treating wastewater is to remove the organic carbon and other nutrients from the water. If these nutrient sources are not removed, when the water reaches the lakes it will affect the eco-system of that body of water. For example, excess nitrogen is diegested by algae and causes excess growth of the algae. The algae uses up oxygen from the water to grow and to digest the nutrients found in the wastewater. The depletion of oxygen in the water kills other life that is dependent on it such as fish.

Four Corners Activity: In each corner of the room there are equations involving the breakdown of wastewater material. In your corner you will determine the amount of carbon dioxide created by your reaction and compare it with the other four corners. As a class you will determine which reaction produces the most carbon dioxide.

Corner1: Estrogen is found in many pharmaceuticals and in biologically enhanced foods

Estrogen: $C_{18}H_{24}O_2$ +23 O_2 -> $18CO_2$ + $12H_2O$

Start with 20g Estrogen

Corner 2: Casein is a protein found in milk products and digested

$C_8H_{12}N_20_3$ + 3 O_2 -> $C_5H_7O_2N$ + NH_3 + $3CO_2$ + H_2O

$C_5H_7O_2N$ IS BACTERIAL CELL

$C_8H_{12}N_20_3$ IS CASEIN

Start with 30g Casein

Corner 3: urea is a product found in urine

NH_2COHN_2 + H_2O + $7H^+$ -> $3NH4^+$ + CO_2

Turning urea to ammonium

Start with 60g urea

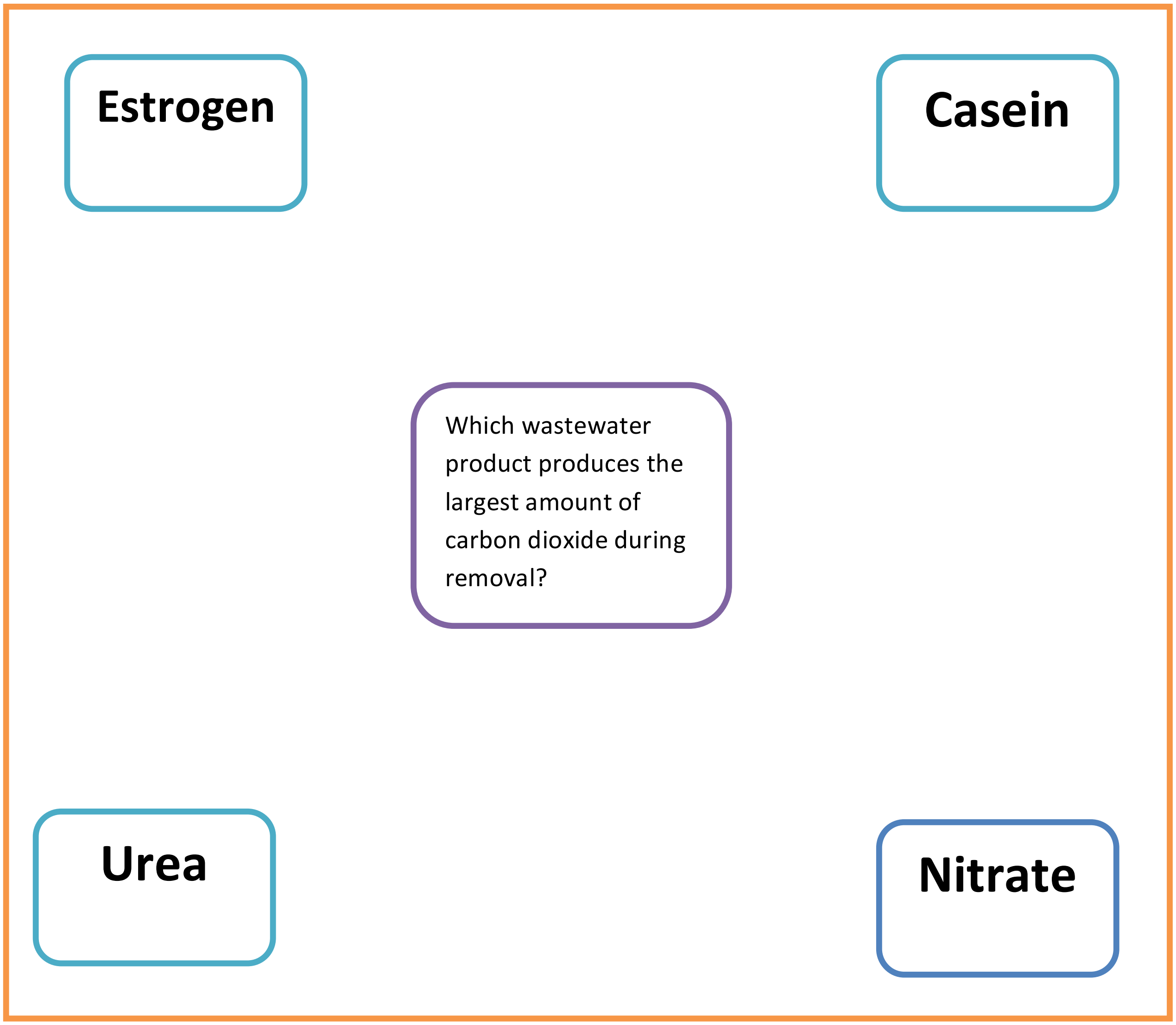
Corner 4:

$6NO_3^-$ + $5CH_3OH$ -> $3N_2$ + $5CO_2$+ $7H_2O$ + 6OH

Turing nitrate into nitrogen gas

Start with 20g nitrate

Four Corners Classroom Layout:



C.2 Homework Worksheet

Solve the following stoichiometry problems:

1) Using the following equation:

$$2\ NaOH + H_2SO_4 \rightarrow 2\ H_2O + Na_2SO_4$$

How many grams of sodium sulfate will be formed if you start with 1.25L of a 4 M solution of sodium hydroxide and you have an excess of sulfuric acid?

2) Using the following equation:

$$Pb(SO_4)_2 + 4\ LiNO_3 \rightarrow Pb(NO_3)_4 + 2\ Li_2SO_4$$

How many grams of lithium nitrate will be needed to make 250 grams of lithium sulfate, assuming that you have an adequate amount of lead (IV) sulfate to do the reaction?

Quick Tip!
When doing stoichiometry problems, people are frequently worried by statements such as "if you have an excess of (compound X)". This statement shouldn't worry you… what it really means is that this isn't a limiting reagent problem, so you can totally ignore whatever reagent you have an excess of. Don't even give it a second thought, because if you do, you'll run into trouble.

3) Write the balanced equation for the reaction of acetic acid with aluminum hydroxide to form water and aluminum acetate:

4) Using the equation from problem #3, determine the mass of aluminum acetate that can be made if I do this reaction with 125 grams of acetic acid and 275 grams of aluminum hydroxide.

5) What is the limiting reagent in problem #4?

6) How much of the excess reagent will be left over after the reaction is complete?

C. 3 Homework Solutions

1) 355.3 grams of Na_2SO_4

2) 313.6 grams of $LiNO_3$

3) Write the balanced equation for the reaction of acetic acid with aluminum hydroxide to form water and aluminum acetate:

$$3\ C_2H_3O_2H + Al(OH)_3 \rightarrow Al(C_2H_3O_2)_3 + 3\ H_2O$$

4) Using the equation from problem #3, determine the mass of aluminum acetate that can be made if I do this reaction with 125 grams of acetic acid and 275 grams of aluminum hydroxide.

Two calculations are required. One determines the quantity of aluminum acetate that can be made with 125 grams of acetic acid and the other determines the quantity of aluminum acetate that can be made using 275 grams of aluminum hydroxide. The smaller of these two answers is correct, and the reagent that leads to this answer is the limiting reagent. Both calculations are shown below – the correct answer is circled.

$$\frac{125\,g\ C_2H_3O_2H}{} \left| \frac{1\,mol\ C_2H_3O_2H}{60\,g\ C_2H_3O_2H} \right| \frac{1\,mol\ Al(C_2H_3O_2)_3}{3\,mol\ C_2H_3O_2H} \left| \frac{204\,g\ Al(C_2H_3O_2)_3}{1\,mol\ Al(C_2H_3O_2)_3} \right.$$

$$= 141\,g\ Al(C_2H_3O_2)_3$$

$$\frac{275\,g\ Al(OH)_3}{} \left| \frac{1\,mol\ Al(OH)_3}{78\,g\ Al(OH)_3} \right| \frac{1\,mol\ Al(C_2H_3O_2)_3}{1\,mol\ Al(OH)_3} \left| \frac{204\,g\ Al(C_2H_3O_2)_3}{1\,mol\ Al(C_2H_3O_2)_3} \right.$$

$$= 719\ grams\ Al(C_2H_3O_2)_3$$

5) What is the limiting reagent in problem #4?

Acetic acid

6) How much of the excess reagent will be left over after the reaction is complete?

$$275\,g\ Al(OH)_3 - \left[275\,g\ Al(OH)_3 \left(\frac{141\,g}{719\,g} \right) \right] = 221\,g\ Al(OH)_3$$